

Gill Instruments: environmental & industrial monitoring solutions	
Technical Key Note	

WindMaster™

WindMaster™ PRO

Key Note Series Number	KN1509v6*
Subject	Software bug affecting 'w' wind component of the WindMaster family
Applicable models	WindMaster / WindMaster Pro
Date:	8 th July 2016

***This note has been updated to reflect a new 4th option for customers (a firmware update tool described below in the options section), an updated 'w' bug information for anemometers chart showing the current Nakai and Shimoyama (NS12) Angle of Attack (AoA) correction advice from Gill as well as to include some data plots showing the performance of the asymmetrical 'w' correction as verified by 3rd party independent data (using NS12 data).**

Software bug affecting 'w' wind component notice and available options to customers:

Description of the 'w' bug: (affects WM/WM Pro products between 2006 and Oct. 2015)

Gill Instruments has found a 'bug' in some versions of the WindMaster and WindMaster Pro firmware (previously unknown to both Gill and the community) from internal research looking at the Angle of Attack (AoA) corrections for various wind vectors and now confirmed by separate work done by the AmeriFlux Tech Team (please see the poster presented at the 2014 AGU meeting titled: Vertical wind in sonic anemometers: observations from AmeriFlux QA/QC site visits). The 'bug' affecting some models is effectively that there is no mechanical 'maths' correction applied for the vertical 'w' axis wind measurement at the most basic level of signal processing. All other Gill 3 axis anemometers (R series/ HS series) have this 'w' correction implemented correctly. The correction factor that has been missing is a significant boost in the 'w' wind component (compared to previous outputs from the WM / WM Pro) which can be seen below:

+W correction +16.6% (multiplication factor of x 1.166).

-W correction +28.9% (multiplication factor of x 1.289).

This simple scaling factor correction (when applied) will provide excellent 3 dimensional wind accuracy results within stated specification wind speed and incidence angle from horizontal (± 30 degrees). In addition, this correction will assist in providing better accuracy at AoA greater than ± 30 degrees, although with decreasing benefit, up to ± 60 degrees from horizontal. The 'w' bug does not affect the other wind components and strictly affects only the 'w' component.

Options available to Gill WindMaster and WindMaster Pro users:

There are several options available to users to correct for this bug, both for previously collected data and for any future data collection needs: (NEW 4th Option available: firmware update tool).

- 1) For users of WM/WM Pro products only, and for production dates between 2006 and Oct. 2015 only (see attached table for more info), the bug correction is a simple multiplication linear scaling factor (+w = x 1.166, -w = x 1.289), users can correct any RAW anemometer data 'w' component values and then recalculate fluxes with the new correct w parameter. Through this process, users can post process data and/or adapt their data collection devices to modify the 'w' values of existing WM/WM Pro products to achieve the correct 'w' measurements. For previously collected data from anemometers affected with this software bug, LI-COR is developing a feature in their EddyPro Software that will appropriately apply these multipliers to the raw data, which can then be reprocessed to obtain accurate fluxes. This feature will be available in the version released in Summer 2016.

Page 1 of 6

Gill Instruments: environmental & industrial monitoring solutions	
Technical Key Note	

- 2) Users of WindMaster/WindMaster Pro products from 2006 until Oct. 2015 and software versions up to 2329 v 601 which have this 'w' bug (please see attached table to help determine which product generation/firmware version you may have, or contact Gill with the serial number of your WindMaster/WindMaster Pro for further assistance.) can use the NS12 AoA published corrections unaltered which include this 'w' boost scaling factor in the AoA correction (please be aware that the NS12 AoA corrections assume symmetry for both +w and -w which field and wind tunnel tests have recently shown to be asymmetrical, please see data plots below, further scientific follow up work on this topic will be published in the future). Please note that users should not apply any community derived AoA corrections such as NS12 if 'w' has been corrected as this will overcompensate.
- 3) Users of WM / WM Pro products (all versions up to Oct. 2015) can upgrade their products for a reduced fee to the latest build standard which includes the 'w' bug fix as well as the latest improvements to sonic Temperature (Ts) for a limited time. This upgrade involves replacement transducers, stalks as well as wind tunnel calibration work in addition to the firmware bug fix. This option is for those users wishing to upgrade their ultrasonic anemometer to the latest standards and primarily wish to have the sonic temperature improvements (but will receive the 'w' bug correction in addition). Full service and repair support for older versions of WindMaster family products continues to be offered by Gill and this will not change for the foreseeable future. For pricing and lead times please contact your Gill representative or Gill instruments direct where appropriate.
- 4) For users of WM/WM Pro products only, and for production dates between 2006 and Oct. 2015 only (see attached table for more info), a firmware update tool has been developed to allow users to update their anemometer(s) to correctly calculate and output the 'w' wind component. This update tool is free of charge and can be requested from Gill Instruments or your local Gill sales / support channel. For details of the upgrade process or to request the upgrade please contact your local Gill sales / support channel (where appropriate) or Gill directly at: Gill Technical Support Team
anemsupport@gillinstruments.com
+44 (0)1590-613500 (then choose the option for technical support)

Gill will publish this technical note on the Gill website (under the support section), as well as inform users of these products at conferences and exhibitions. Gill has also provided the above notice (in a modified format) in the latest versions of the WM/WM Pro manuals available on the Gill website and with each new product. Other notices and publication work, together with the community and partners may also follow as deemed appropriate to help inform users of this bug, the work arounds and solutions.

For any questions regarding this bug, the options available to you to correct for the missing 'w' scaling factor, or to discuss more on AoA, the following contact details are available to discuss this or any other service / support need with our technical team:

Gill Technical Support Team
anemsupport@gillinstruments.com
+44 (0)1590-613500 (then choose the option for technical support)

Please see the attached table for more information on what corrections are applied regarding Gill products and revisions. Contact Gill if you have any questions in this regard.

Gill Instruments: environmental & industrial monitoring solutions	
Technical Key Note	

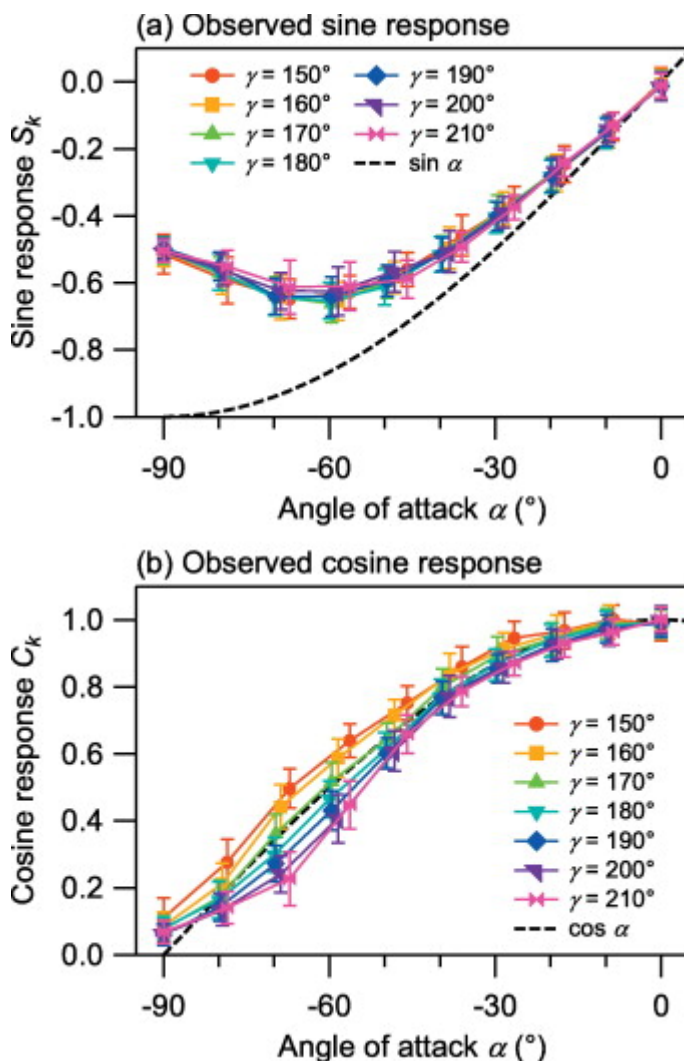
Model	Is the 'w' bug present? (in some versions)	Nakai & Shimoyama 2012 (NS12) AoA corrections applicable?	Ways to Identify 'w' bug affected anemometers				
			Production dates of affected units	Firmware version # (D2 command) of affected units	Head support spar colour of affected units	Transducer Stalk colour of affected units	Other helpful info to determine if affected
WindMaster	Yes, if serial number starts with Y (X or W denoted units do not have the bug)	YES, if 'w' bug has not been corrected. Otherwise, only in a modified version for AoA steeper than $\pm 50^\circ$ (sine response) or potentially for any AoA for cosine response.	From 2006 to Oct 2015	up to 2329 v 601	Blue	Black	Serial Number starts with Y
WindMaster Pro	Yes, if serial number starts with Y (X or W denoted units do not have the bug)	YES, if 'w' bug has not been corrected. Otherwise, only in a modified version for AoA steeper than $\pm 50^\circ$ (sine response) or potentially for any AoA for cosine response.	From 2006 to Oct 2015	up to 2329 v 601	Stainless Steel	Black	Serial Number starts with Y
All Other Gill Anemometer Products (including WM/WM Pro versions manufactured before or after the dates mentioned above in the table)	No	Principle sound however incorrect coefficients (as the WM 'w' bug boost correction is erroneously included)					

Technical Key Note

The below data plots show; 1) (Uncorrected 'w' bug) observed sine response as a function of AoA for a WM, 2) (Corrected using Gill derived '-w' correction values) improved sine response as a function of AoA using same data set. 3) Asymmetrical behaviour in the sine response (as proposed by Gill) for $-w$ and $+w$ showing good agreement using NS12 data.

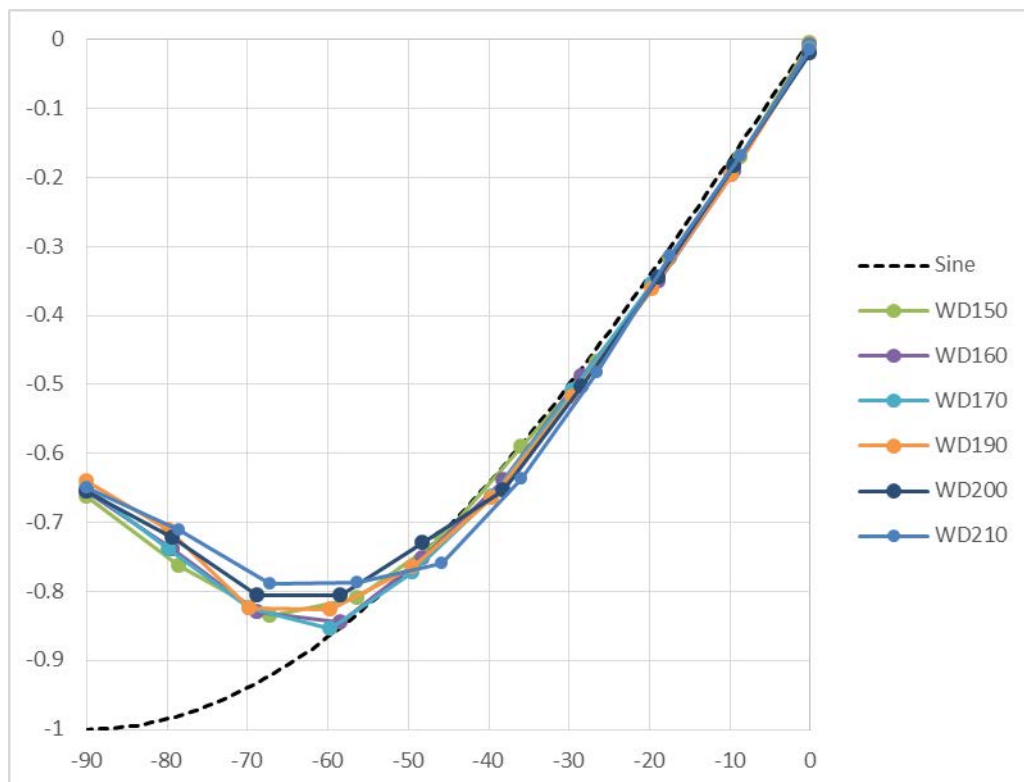
All data plots reproduced with kind permission of the authors (Nakai & Shimoyama) from the publication 'Nakai, T. and Shimoyama, K. Ultrasonic anemometer angle of attack errors under turbulent conditions. *Agric. For. Meteorol.*, **162–163**, 14–26, 2012' along with new data plots showing post processed results from the same data set using Gill derived 'w' correction factors mentioned in this technical keynote. The authors have stated they wish to publish further information on this in a future paper.

- 1) Observed sine and cosine response from WM anemometers with the 'w' bug (without the NS12 corrections applied). The black dotted line represents the ideal response. The uncorrected data shows the observed sine response for - AoA beyond 10 degrees (from horizontal) requires correction.



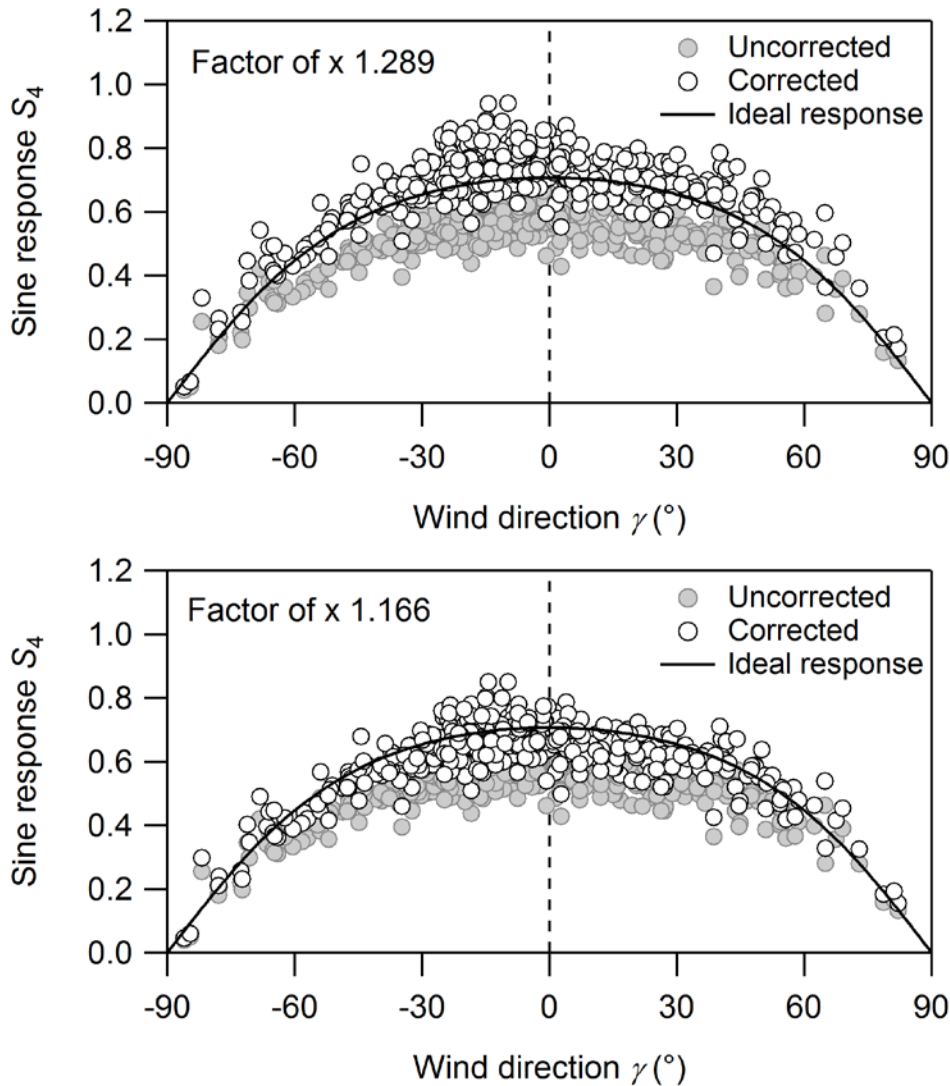
Technical Key Note

- 2) Sine response from the same data set (NS12) after applying the proposed Gill wind tunnel derived - w correction factor (1.289). The black dotted line represents the ideal response. The corrected data shows greatly improved sine response for AoA up to 50°.



Technical Key Note

- 3) The + w correction factor derived in the Gill wind tunnel applied to the NS12 data (at fixed +45° AoA and across a wind direction range of $\pm 90^\circ$) shows better agreement to the ideal sine response (bottom graph using correction factor of 1.166) compared to the top graph which represents the overcompensation if the - w correction factor of 1.289 is used.



Summary of Data Plots:

Plots 1a and 2 above show that NS12 field data correlates closely with Gill wind tunnel data for sine response for negative AoA. Once the 'w' bug is corrected, the residual sine response correction per NS12 is only required above about -50° AoA.

Plot 3 shows that, for the limited positive AoA data available from NS12, the asymmetry in sine response for $\pm$ AoA as proposed by Gill is supported, however further field measurements are required to validate the precise factor proposed by Gill.

It should be noted that the NS12 cosine corrections are totally unaffected by the "w" bug.

All data shown copyright of the authors (NS12), reproduced with kind permission.

End of technical keynote.